**Lecture: Fermentation**

**Date: 4/9/2011**

History:

Humans have been brewing beer for thousands of years, but science has only recently allowed us to understand the biochemistry specifics of how beer is formed. People knew there was the “right stuff” necessary to convert grain into beer and bread. The yeast harvested at the end of fermentation was called “godisgood”, brewers maintained a brewing paddle which they would place in each batch in order to inoculate their wort with yeast, and the first German purity law “Reinheitsgebot” did not even mention yeast as one of the necessary ingredients.

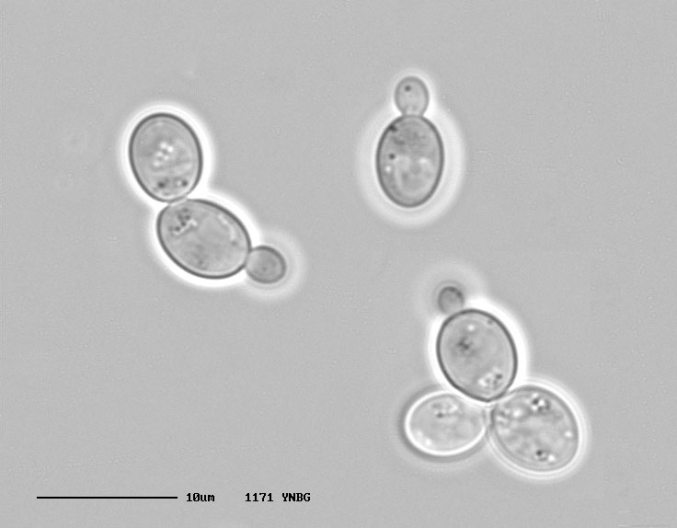
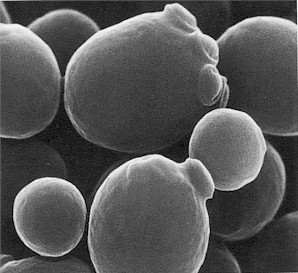
Yeast was discovered in waves of discoveries:

1680: Antonie van Leeuwenhoek “Father of Microbiology” noticed yeast cells

1810: Gay-Lussac, established the stoichiometry of glucose conversion to ethanol and carbon dioxide

1836 Friedriech Traugott KuÈtzing and Charles Cagniard-Latour – Observed yeast budding and growing

1876 Louis Pasteaur – Observed yeast fermentation and contamination from bacteria



**Saccharomyces cerevisiae**

**Saccharomyces-** Latin/Greek for Sugar Mold

**Cerevisiae-** Latin for Beer

Yeast are heterotrophic, facultative anaerobic organisms

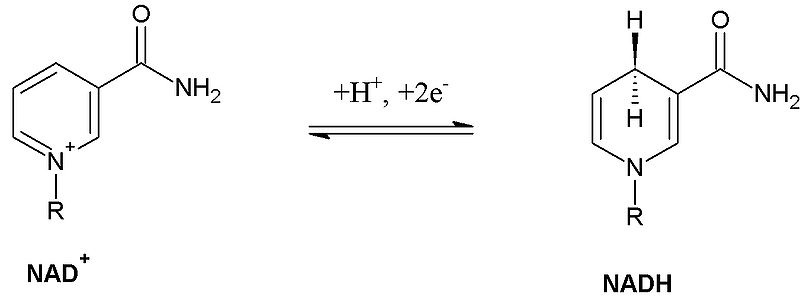
Heterotrophic refers to the fact that they need to consume organic carbon (glucose) to produce energy

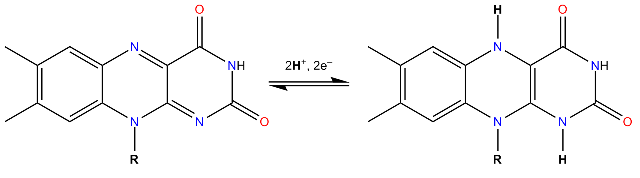
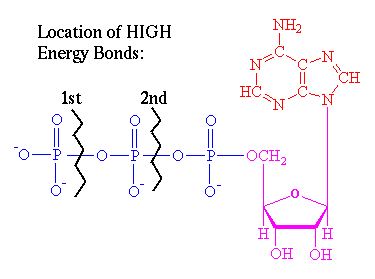
Facultative refers to the ability of yeast to switch to between aerobic respiration and fermentation to generate ATP

Anaerobic refers to the ability to survive in an oxygen free environment

ATP: (Adenosine Tri-phosphate) is a molecule used by cells that stores energy for use in cellular activities

NADH: (Nicotinamide adenine dinucleotide) Molecule used by cells to facilitate energy production/transfer

FAD: (flavin adenine dinucleotide) Molecule used in metabolism to facilitate energy production/transfer



**ATP**

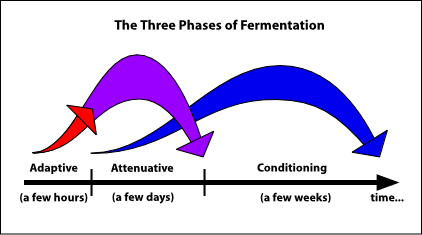
**FADH2**

**FAD**

Anabolic pathway – Metabolic pathways that use energy released from catabolic pathways to form new molecules

Catabolic pathway – Metabolic pathways that break apart bonds in molecules to release stored energy

The Fermentation Process Occurs in 3 stages:

1. The Uptake Period
2. Aerobic Respiration
3. Anaerobic Fermentation

**The Uptake Period:** Building Materials are Gathered

Oxygen in the wort is absorbed by the yeast

-This will provide the reducing power necessary for respiration

-Process occurs within hours after pitching yeast

Sugars and Nitrogen are absorbed next (Adaptive phase)

**Aerobic Respiration**: Building Energy Reserves and Multiplying

Glycolysis – On Board

Citric Acid Cycle – On Board

Oxidative Phosphorylation – On Board

**Yeast Cells Bud – On Board**

50% “new”

25% “1 birth scar”

12.5% “2 birth scars”

6.25% “3 birth scars”

Etc.

**Anaerobic Fermentation**: Ethanol and Carbon Dioxide Production

Oxygen is used to generate NAD+

Glycolysis – On Board

-New yeast cells do not form

-Primary production of ethanol and carbon dioxide

Sugars are consumed in order of simplest to more complex.

Yeast do not have the energy required to break down higher order sugars such as malto-tetraose